

MEMORANDUM FOR: William Stone
Geodetic Advisor to the State of New Mexico

FROM: Charles W. Challstrom
Director, National Geodetic Survey

SUBJECT: INSTRUCTIONS: GPS ON ABSOLUTE GRAVITY
STATIONS
IN YELLOWSTONE PARK, WYOMING (GPS-1527)
Task Number: 8K6D2000

GENERAL:

The National Geodetic Survey (NGS) is partnering with NOAA's Laboratory for Satellite Altimetry (LSA) in their effort to measure crustal deformation in the Yellowstone Caldera. NGS will provide equipment and expertise for both FG-5 absolute gravity and GPS measurements. Micro-G Systems, under contract to NOAA/LSA, will provide equipment and expertise for A-10 absolute gravity observations.

Approximately 10 to 15 absolute gravity stations will be occupied in this project using three dual-frequency full-wavelength GPS receivers. Final station selection will be made by Dr. Anahita Tikku of LSA.

FG5 absolute gravity measurements and related peripheral measurements (gradients, excenter ties, environmental monitoring, etc.) are needed at two sites in Yellowstone National Park, Wyoming, to provide sub-five microgal precision stations. These measurements supplement A-10 absolute gravity measurements, GPS observations, and associated surveying in a study of elevation changes in the Yellowstone caldera. Two sites will be selected from various indoor candidate sites in Canyon Village, Mammoth, Old Faithful, and Lake.

The GPS and FG-5 portions of the project will be performed under the technical management of NGS.

N/NGS21:DHendrickson:713-3194:amg:09-12-00
A:\YELGPS

PURPOSE:

The Yellowstone Caldera is an active volcanic area at the end of the Snake River Plateau - Yellowstone hotspot chain that is completely contained within Yellowstone National Park. Precise GPS measurement will supplement absolute gravity measurements and will serve as a baseline for future measurements of the crustal deformation of the caldera.

SPECIFICATIONS:

Project requirements for the observations are to ensure 1 centimeter local accuracy in the ellipsoid height component.

Data from one National CORS, two University of Utah/UNAVCO base stations, and two U.S. Geological Survey (USGS) base stations in the immediate area are to be used in the processing.

The National CORS is Mammoth (MAWY). The two University of Utah/UNAVCO base stations are Old Faithful (OFWY) and Lake NSN (LKWY). The two USGS base stations are Hayden Valley (HYWY) and White Lake (WLWY).

Positions and data for the Mammoth CORS are available from the NGS web site. Positions and data for the two University of Utah/UNAVCO and the two USGS base stations are available from the following web site:

<http://www.mines.utah.edu/~rbsmith/RESEARCH/UUGPS.html>

The stations are to be occupied for one 12-hour (overnight) session each, although, if a station is within 5 km of either the Mammoth CORS, the University of Utah/UNAVCO base stations, or the USGS base stations, and is clear of obstructions (clear sky visibility), the following observing procedure may be substituted:

Two 2-hour sessions on different days with 4 to 6 hours difference in the start time.

However, if possible, the 12-hour sessions should be used.

(The determination of whether any stations are within 5 km of one the base stations or the Mammoth CORS will be made by Anahita Tikku.)

Observing windows have been selected, and for the 12-hour over-night sessions, the observations will begin at 0000 UTC (6:00 PM local time) and end at 1200 UTC (6:00 AM local time the next morning).

If two 2-hour sessions on different days are used, they will begin at 1600 UTC (10:00 AM local time) on one day and 2130 UTC (3:30 PM local time) the next day.

The stations shall be observed continuously throughout the windows.

FG5 sites will be sampled for 48 hours if the site is on soil or 24 hours if the site is on rock. Sampling will be one drop every 10 seconds and 100 drops per set per hour. Normal indoor set-up, mark setting, and documentation will be done. Vertical gravity gradient measurements will be made with 1 or 2 relative gravity meters between heights of 91 cm and 131 cm with the floor. Excenters should be established and observed unless A-10 measurements supercede them. If operationally convenient, FG5 sites and/or excenters should have elevation or horizontal control brought to it. The field operator has discretion to modify these specifications depending on field conditions.

In general, station occupation and observing procedures must be carried out according to appropriate sections of the "NGS Operations Handbook" and the current applicable receiver field manuals. Data formats and digital file definitions are given in "Input Formats and Specifications of the National Geodetic Survey Data Base," Volume I. Horizontal Control Data, Federal Geodetic Control Subcommittee, September 1994, revised and reprinted November 1998. Success in meeting the accuracy standards will be based on repeatability of measurements and adjustment residuals.

General specifications for the project are given in "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques," Version 5.0: dated May 11, 1988, reprinted with corrections August 1, 1989. Specific project criteria and deviations from the general specifications are given in the following sections.

Project Network - A list (Table 1) and sketch of stations involved in this project will be provided.

Data Acquisition - Data collection must be accomplished as specified in the appropriate dual-frequency receiver field manuals in the compressed mode at a 15-second epoch collection interval. The GPS receivers must be dual-frequency and full-wavelength. Track satellites down to a 10-degree elevation angle.

Record weather data just before and immediately after each session. Meteorological data shall also be collected immediately after an obvious weather front passes during a session and immediately before it passes, if possible. Pressure and relative humidity measurements must be made near and at about the height of the GPS antenna phase center. Indicate in the log the location of the barometer and psychrometer.

Vector Computations - Data management, quality review of collected data, and final vector processing using PAGES will be accomplished by LSA, E/RA31, with assistance from NGS' Spatial Reference System Division, N/NGS2. Vectors shall be computed in the International Earth Rotation Service Terrestrial Reference Frame (ITRF) system, using the most current epoch and precise IGS ephemerides. Use 30-second epoch intervals for data processing. Monument positions will be used for the CORS and base stations when available, otherwise, antenna reference point (ARP) positions will be used. Use 15 degrees as the cutoff elevation angle in data processing. A cutoff angle of 10 degrees may be used when necessary to improve results.

The type of final solution, L1 versus ion-free, will depend on the length of the vectors. For vectors which are less than 5 km in length, the final reduction will consist of a L1 fixed solution. These vectors will be computed in a separate processing session from the longer vectors computed in an ion-free solution. Vectors between 5 to 10 km in length may be computed in an L1 or an ion-free solution, whichever produces the cleanest results.

In general, vectors greater than 10 km in length are to be computed in an ion-free fixed, or partially-fixed, solution. In all cases, integer ambiguities will be fixed for each vector whenever possible.

The quality of collected data shall be determined from the plots generated from PAGES, by analysis of repeated vectors

and/or comparison of station positions, and free adjustment residuals and/or loop misclosures. In addition, a constrained adjustment constraining the CORS and all base stations will be performed.

N/NGS2 will perform all quality checks for conformance with NGS format standards such as executing software programs COMPGb, OBSCHK, and OBSDES. N/NGS2 will assess the final ITRF vectors and transfer them to the NAD 83 coordinate system using program ADJUST.

Station Descriptions - Station recovery notes must be submitted in computer-readable form using WDDPROC software. Include the name, address, and, if public ownership, the telephone number of the responsible party. Mr. Bill Stone will be responsible for submitting the descriptions.

Special Requirements - Antenna set-up is critical to the success of this project. Fixed-height tripods are preferred for all receivers. The plumbing bubbles on the antenna pole of the fixed-height tripod must be shaded when plumbing is performed. They must be shaded for 3 minutes before checking and/or re-plumbing. Also, the perpendicularity of the poles must be checked at the beginning of the project and any other time there is suspicion of a problem.

When a fixed-height tripod is not used, the height of the antenna must be carefully measured to prevent station set-up blunders from occurring. Tribrachs used for these set-ups must be checked and adjusted when necessary. Totally independent measurements of the antenna height above the mark in both metric and English units must be made before and after each session. Someone other than the observer must check the measurement computations by carefully comparing measurements and then entering his/her initials on the log.

Some GPS antennas have detachable ground planes and radomes. In order to help identify what exactly was used at a particular site, it would be useful to have a snapshot of the setup. All observers should take a photograph of the setup, if possible, with a close-up of the antenna as viewed from the side.

In addition, a rubbing of the stamping of the mark must be made at each visit to a station. If it is impossible to make a rubbing of the mark, a plan sketch of the mark must be substituted, accurately recording all markings.

Also, for each station visited, a visibility obstruction diagram must be prepared and the TO-REACH description carefully checked for errors or omissions.

Lastly, the following must be recorded at each occupation of a station:

- (1) receiver manufacturer,
- (2) antenna manufacturer,
- (3) receiver model number (part number),
- (4) antenna model number (part number),
- (5) the complete serial number of the receiver, and
- (6) the complete serial number of the antenna.

Success of this project requires that the highest quality GPS data be collected. Therefore, during each station occupation, the operators shall carefully monitor the operation of the receivers. Any irregularities in the data due to equipment malfunction, DOD adjustment of the satellite orbit, obstructions, etc., must be reported to the Project Development Branch, N/NGS21, as soon as possible and noted on the observing log. If the quality of observations for an observing session is questionable, notify the Project Development Branch immediately.

The survey team shall not depart the project area until they have quality reviewed all data and advised N/NGS21 and E/RA31.

GPS DATA:

Visibility tables and plots of the present satellite constellation for September 12, 2000, have been reviewed and a observing window selected. For operational use, current data must be generated with Trimble mission planning software or from program SATMAP.

Project report and data listed in Annex L of "Input Formats and Specifications of the NGS Data Base" and in the attached addendum for the adjustment portion must be transmitted. Any data considered suspect as to quality in achieving accuracy standards should be sent via FedEx immediately for office

review. Backup of transmitted data must be held until notified by the Project Development Branch, N/NGS21.

The data set collected during the project shall be named "yell090d.802". All records in connection with this project shall be titled "GPS ON ABSOLUTE GRAVITY STATIONS IN YELLOWSTONE PARK". The project number (accession number) is GPS-1527.

LIAISON:

Liaison must be maintained with designated offices at the National Geodetic Survey headquarters located at:

1315 East-West Highway
Silver Spring, Maryland 20910-3282

Questions and problems concerning adjustment processing should be directed to:

Maralyn L. Vorhauer
Observation and Analysis Division
N/NGS4, SSMC III, Station 8562
Telephone: 301-713-3176, ext. 104
Fax: 301-713-4327
e-Mail: maralyn@ngs.noaa.gov

Questions and problems concerning using CORS data in processing should be directed to:

Neil Weston
Geosciences Research Division
N/NGS6, SSMC III, Station 9830
Telephone: 301-713-2847, ext. 202
Fax: 301-713-4475
e-Mail: nweston@ngs.noaa.gov

Questions and problems which could affect the technical adequacy of the project should be directed to:

Stephen J. Frakes (Douglas R. Hendrickson)
Chief, Project Development Branch
Spatial Reference System Division
N/NGS21, SSMC III, Station 8853

Telephone: 301-713-3194, ext. 111 (ext. 127)
Fax: 301-713-4316
e-Mail: steve@ngs.noaa.gov (dough@ngs.noaa.gov)

The coordinator for the project is:

William Stone
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Other NOAA contacts for the project are:

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Dan Winester
Geosciences Research Division
N/NGS6
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Fax: 303-497-7406
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Dan Winester's physical address is:

Table Mountain Gravity Observatory
8600 North 39th Street
Longmont, Colorado 80503-9050

The UNAVCO contact is:

Dr. Charles Meertens
UNAVCO/UCAR
P.O. Box 3000
Boulder, Colorado 80307-3000
Telephone: 303-497-8011
e-Mail: chuckm@unavco.ucar.edu

PUBLICITY:

See "NGS Operations Handbook," Section 1.4.1.

EXPENSES:

Expenses for this project will be charged to task number 8K6D2000.

TRAVEL:

Travel and per diem are authorized in accordance with Federal Travel Regulations, Part 301-11, Per Diem Allowances. Current per diem rates were effective January 1, 2000.

ACKNOWLEDGMENT:

Please acknowledge receipt of these instructions in your Monthly Report.

cc: N/NGS - D. Zilkoski*
N/NGS - S. Misenheimer*
N/NGS1 - G. Mitchell
N/NGS1x1 - W. Stone
N/NGS11 - S. Cofer
N/NGS21 - S. Frakes
N/NGS21 - R. Anderson
N/NGS21 - D. Hendrickson*
N/NGS22 - T. Soler
N/NGS3 - E. Allen
N/NGS4 - E. Wade
N/NGS4 - M. Vorhauer
N/NGS4 - D. Hoar
N/NGS5 - R. Snay
N/NGS6 - N. Weston
N/NGS6 - D. Winester
E/RA31 - A. Tikku
E/RA31 - D. McAdoo
FGCS Members*
Dr. Charles Meertens, UNAVCO/UCAR

* first page only

**DATA TO BE SENT TO HEADQUARTERS RELATING TO
THE ADJUSTMENT PORTION OF
FBN/CBN PROJECTS**

Free adjustment in NAD 83 (UNIX run).

Plots of the free adjustment created by running "plotres_prompt.bsh" on a UNIX server. Plots require a printer that supports postscript. The output file (long.out) contains a list of residuals which may be sorted using the following commands:

```
vi long.out
:1,$ !sort +0.47 (sorts horizontal residuals)
:1,$ !sort +0.71 (sorts vertical residuals)
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(OPTIONAL) Constrained horizontal adjustment holding NGS CORS positions and ellipsoid heights.

Final combined Blue Book file (ASCII required) with *86* records (GEOID99).

Final description file (ASCII required.)

Final G-file (ASCII required.)

OBSCHK output.* **

CHKDDESC output.*

OBSDES output.*

*Any errors or warning messages must be explained.
**Errors relating to incomplete *86* records are acceptable.